Report of Screen-Brightness Committee*

THE COMMITTEE has actively embarked on a preliminary survey of a number of representative theaters to determine practical methods for measuring brightness and illumination of motion picture screens. Equipment and test procedures immediately available were used to expedite the initial task of investigating in a few theaters proper measuring techniques, and of determining present brightness and intensity levels in theaters.

The immediate purpose of the committee's program is to gain enough experience concerning specific test procedures to be able to recommend techniques to be used in a more complete survey aimed at obtaining basic information regarding screen illumination and brightness practice in the entire industry. With information available on test methods and present theater practice, it will be possible for the industry and the committee to utilize theater equipment most effectively to achieve desirable standards of brightness.

This progress report deals specifically with the preliminary survey limited to eighteen theaters in the East and Middle West. The committee was very much pleased with the active co-operation afforded by the projectionists, the theater managers, and all other groups connected with the theater survey.

Acknowledgment is due also to the Bell and Howell, Eastman Kodak, General Electric, and National Carbon Companies for supplying the necessary equipment for conducting the survey.

DETERMINATION OF DATA

It was the decision of the committee that in order to obtain complete data for over-all usefulness, it would be necessary to measure the light intensity on the screen, the brightness of the screen, and to record some of the physical dimensions of the theater affecting projection, and some of the details regarding projection equipment.

The measurement of screen illumination was made with each projector separately, with operation entirely normal except for the absence of film. The light intensity was measured at various points on the screen to determine the distribution of the intensity over the

* Presented October 22, 1947, at the SMPE Convention in New York.

surface and also to be able to compute the total lumens incident on the screen. Two different methods of doing this were employed. The one involved a division of the screen area into twelve equal areas

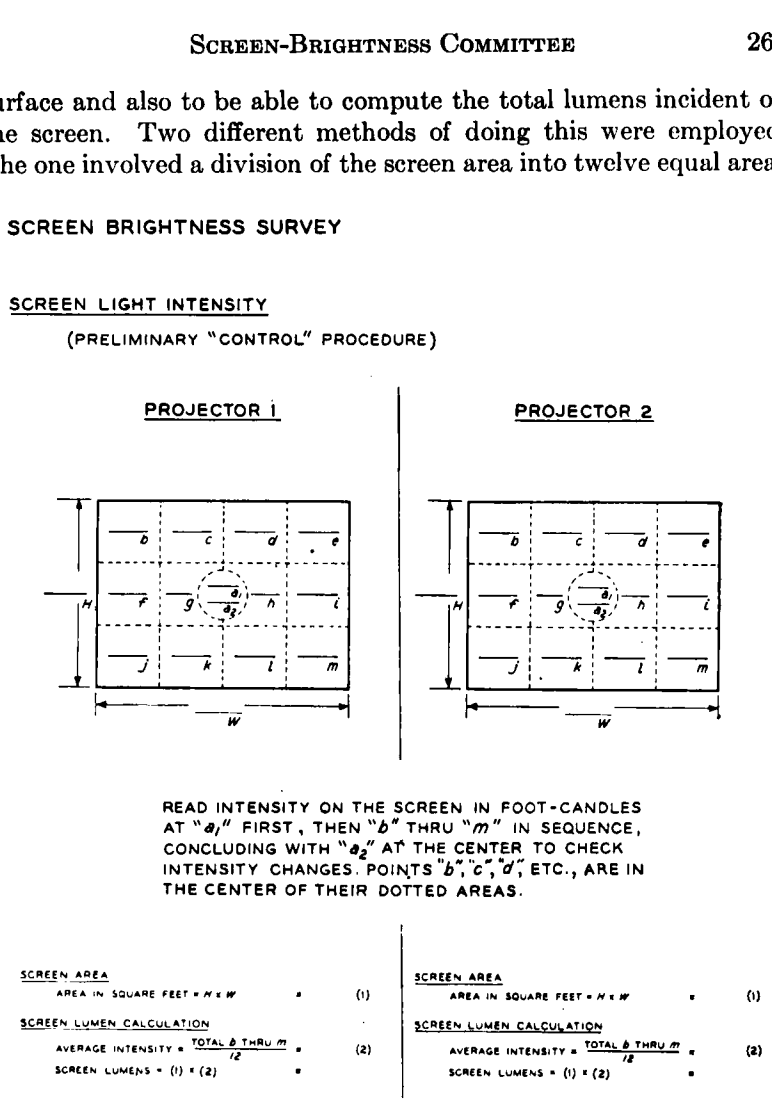


Fig. 1—Sample data sheet for determining screen illumination by the 12-point method.

with the light intensity being measured at the center of each one of these zones. Fig. 1 describes this 12-point method and shows the form of the data sheet used to record the measurements. The other method consisted in measuring the light intensity at the center of the screen, at the upper left- and lower right-hand corners, and at the

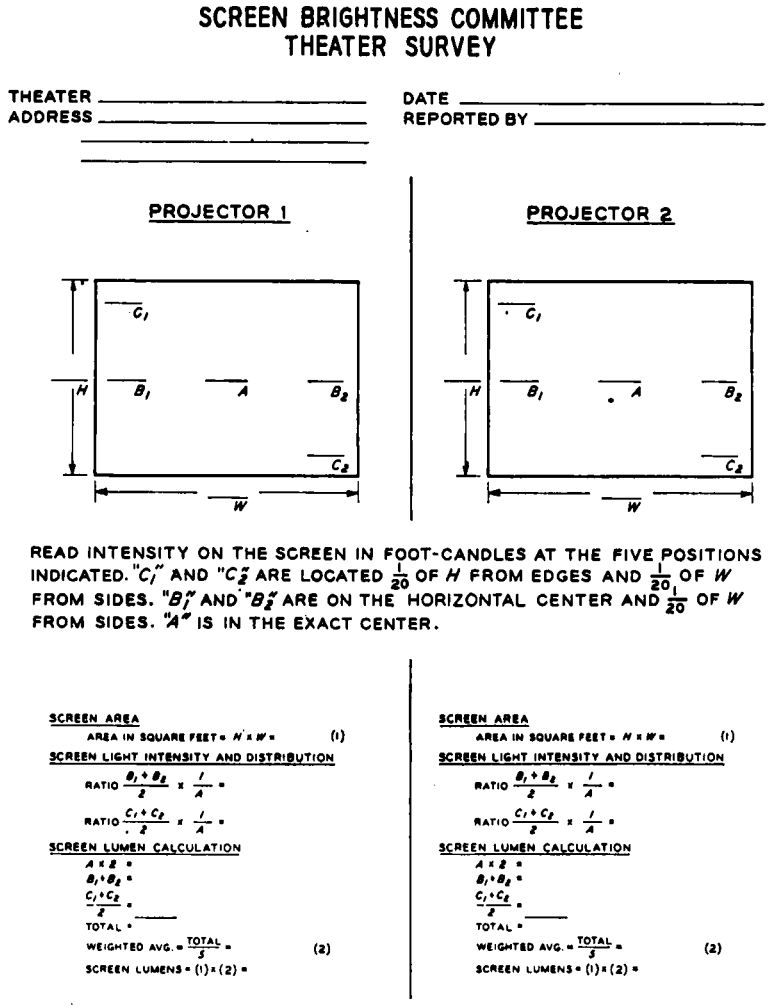


Fig. 2—Sample data sheet for determining screen illumination by the 5-point method.

right and left edges midway between the top and bottom of the screen. The 5-point method is illustrated in Fig. 2. The committee decided to use two methods in this preliminary survey to determine whether the method of 12 equal areas could be supplanted with no loss in accuracy by a quicker 5-, rather than 12-point measurement.

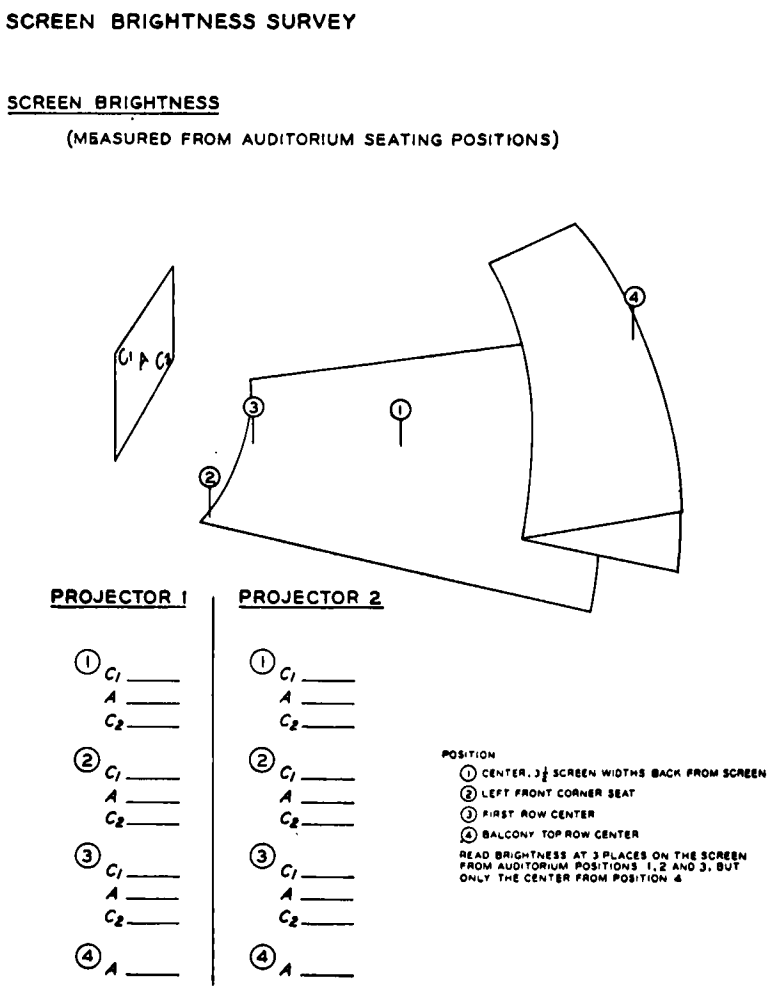


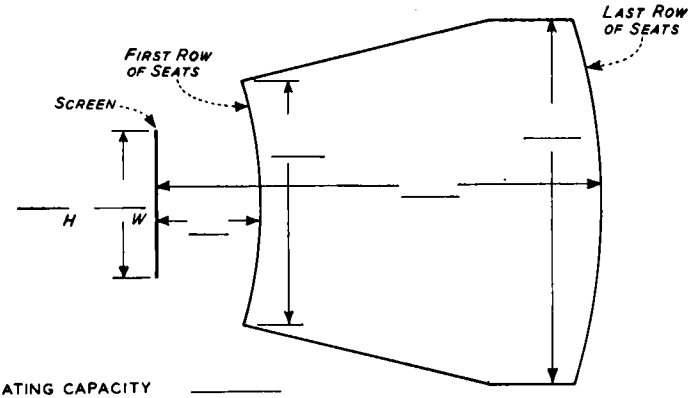
Fig. 3—Sample data sheet showing location of points for brightness measurement.

The equipment used to determine screen-light intensity consisted of a Weston "Photronic" cell corrected for eye sensitivity, and a microammeter, with the cell and meter calibrated in foot-candles. The cell was placed parallel to the screen facing the projector and the determination of incident foot-candles was made from the meter calibration at the various spots discussed and illustrated on the data

sheets. A telescoping pole capable of being extended 20 feet was used to advantage to raise the cell to the proper position on the screen. A tripod mounting equipped with casters facilitated the movement of the telescoping pole across the theater stage.

SCREEN BRIGHTNESS SURVEY

AUDITORIUM DATA



1. SEATING CAPACITY _____
2. HOW MANY BALCONIES _____

PROJECTION DATA

1. DISTANCE FROM APERTURE TO CENTER OF SCREEN _____
2. PROJECTION ANGLE _____
3. ARC LAMP TYPE _____
4. POSITIVE CARBON _____
5. NEGATIVE CARBON _____
6. ARC AMPERES _____
7. ARC VOLTS _____
8. PROJECTION LENS _____
   (a) f/ NUMBER _____
   (b) FOCAL LENGTH _____
   (c) SURFACE COATED YES – NO
9. TYPE OF SHUTTER _____
   (a) DEGREE OPENING _____
10. DRAFT GLASS TYPE _____
11. HEAT FILTER TYPE _____
12. PROJECTION PORT GLASS YES – NO
13. TYPE OF POWER SUPPLY _____
   (a) RATING IN AMPERES _____
   (b) RATING IN VOLTS _____
   (c) OPERATING VOLTAGE _____

Fig. 4—Sample data sheet for recording theater data.

Screen brightness was determined at the time screen-intensity measurements were being made. The brightness measurements were made at the center of the screen and at the upper left- and lower right-hand corners from four positions in the theater. The four positions as shown on the data sheet reproduced in Fig. 3 were in the

center of the theater $3\frac{1}{2}$ screen widths back of the screen, in the center of the first row of seats, the extreme left seat in the first row, and the seat in the middle of the row farthest away from the screen in the highest balcony, if there was one. A Luckiesh-Taylor meter was employed to determine the screen brightness. Since only visual types of meters were immediately available the committee decided to utilize this type in the survey to permit concrete data to be obtained without too much delay. However, it is the intent of the committee to stimulate the development of physical brightness-measuring meters since it is felt that the visual type is not generally satisfactory because of the difficulty due to color differences in the photometer field.

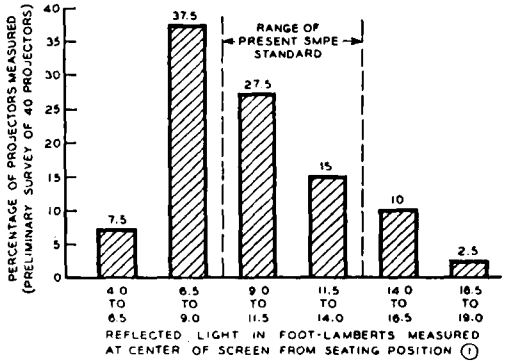


Fig. 5—Range of screen brightness obtained in the survey.

Among the more important theater characteristics which were measured and noted were the screen width and height, the seating plan with relation to the screen, that is, the distance from the screen to first and last rows, the width of the theater at the first and the last row, and the seating capacity. Data on projection equipment were also obtained and these included among other things the projection throw, projection angle, the type of lens, shutter, arc, and power supply. The data sheet used is illustrated in Fig. 4.

Discussion of Data

The results obtained in the preliminary survey of the 18 theaters were representative of houses having screens in the range from 12 feet to 31 feet wide with seating capacities from 300 to 6200 seats and with

projection throws from 65 to 207 feet at projection angles from 5 to 24 degrees.

It was of particular interest to the committee to compare the results obtained on screen brightness with the 9- to 14-foot-lambert standard now in effect. After the brightness data were analyzed, one fact stood out. Approximately 50 per cent of the theaters had a screen brightness at or below the minimum recommended value. The data are summarized in Fig. 5 where there is plotted the percentages of the projectors—there were 40 projectors in the 18 theaters—which resulted in screen brightnesses in the indicated ranges. Only 12.5 per cent (5 projectors) exceeded the recommended maximum.

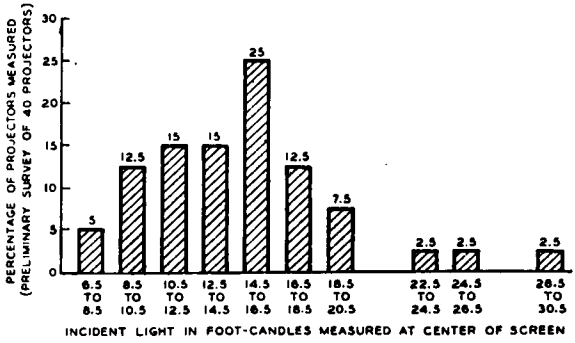


Fig. 6—Range of foot-candles incident intensity obtained in the survey.

Of interest to the committee also, was the light-intensity distribution over the screen and the total lumens on the screen. The foot-candle intensity at the center of the screen in these 18 theaters, varied from a minimum of 7 to a maximum of 30. The range of incident foot-candle intensities is shown in Fig. 6. Approximately one half of the projectors gave from 10.5 to 16.5 foot-candles.

An analysis of the distribution of light intensity over the screen showed that about two thirds of the projectors provided 50 to 75 per cent as much light at the sides as at the center. One projector provided only one third as much light at the side as at the center and in three cases the ratio was over 90 per cent. The ratio of corner-to-center light generally fell in the range 45 to 65 per cent, although in one case it was as low as 25 per cent and at the other extreme ran as high as 75 per cent.

TABLE I
COMPARISON—5- VERSUS 12-POINT METHOD TO DETERMINE SCREEN LUMENS

Theater Number	1		2		3		4		5		6		7		8	
Projector	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Screen lumens, 5-pt	1630	1320	3040	2910	3250	4500	3000	2570	4340	5100	2910	3500	2340	2140	1510	..
Screen lumens, 12-pt	1550	1750	3240	3160	4150	..	3160	2400	3820	5220	2150	2850	2100	2170	1480	..
Ratio, 5-pt to 12-pt	0.95	0.75	0.94	0.92	0.78	..	0.95	1.01	1.13	0.98	1.35	1.23	1.11	0.99	1.02	..

Theater Number	9		10			11			12		14		17		18	
Projector	1	2	1	2	3	1	2	3	1	2	1	2	1	2	1	2
Screen lumens, 5-pt	2360	1590	3950	4525	3810	5550	4840	5320	3180	2820	1765	1630	2500	2300	2950	2580
Screen lumens, 12-pt	2240	1660	3620	4775	4200	5800	5000	5100	3460	3370	1650	1690	2300	2260	2660	2580
Ratio, 5-pt to 12-pt	1.06	0.96	1.09	0.95	0.91	0.96	0.97	1.04	0.92	0.84	1.07	0.97	1.09	1.02	1.10	1.00

Average ratio for all tests 1.002

The total luminous flux falling on the screens was calculated using both the 12-point and 5-point methods. The data are summarized in Table I. The results show no significant difference between the two methods, the average ratio of all results being 1.00. Because of this finding and the fact that the 5-point method is faster and simpler, the committee is inclined toward its use.

Estimates were also made of the screen lumens expected to be available on the basis of our knowledge of the equipment in use in each theater and the measurements recently published[1] on expected output of various types of projection systems. Generally, it was found that the screen lumens obtained fell below the expected values.

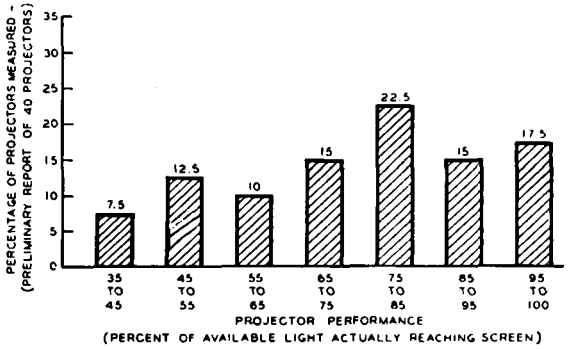


Fig. 7—Ratio of screen lumens observed in survey to that estimated available from laboratory measurements[1] on same type equipment.

The ratio of the screen lumens actually obtained to the expected values are shown in Fig. 7. Seventeen and one half per cent of the projectors obtained practically all the light to be expected from their equipment. On the other end of the scale, 7.5 were obtaining only 35 to 45 per cent of that estimated obtainable. About half of the cases resulted in from 35 to 75 per cent of the expected light while the other half obtained between 75 per cent and all of the light available. The reason for these deficiencies were not determined. However, it is felt that proper search would lead to corrections to minimize these differences.

With data available on light intensity on the center of the screen and brightness at the center, it was possible to calculate reflectivity for the matte screens encountered in the 18 theaters. The results are

shown in Fig. 8. The general average level of the reflectivity of the screens was approximately 70 per cent. Accurate reflectivity figures in individual cases were limited by difficulties in obtaining good visual-brightness values with the visual-brightness meter. This undoubtedly is partly responsible for the extremely high values of reflectivity in two theaters and possibly some of the low values, though in this case, deterioration is visualized as the major factor.

FURTHER PLANS OF THE COMMITTEE

It is recognized, of course, that the results obtained in a preliminary survey of 18 theaters are not conclusive evidence of the experience to be found in the approximately 19,000 theaters in the country.

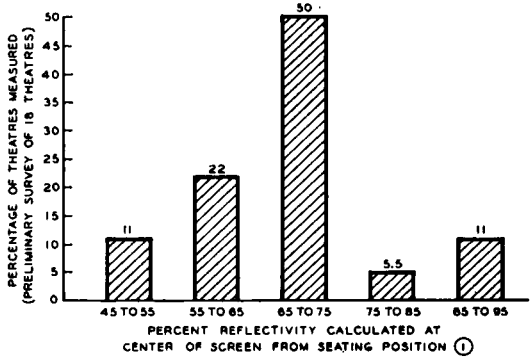


Fig. 8—Range of screen reflectivities obtained in the survey.

Therefore, this progress report is only indicative rather than conclusive and must be followed by a more thorough examination on rather sound statistical grounds before any conclusions can be drawn regarding the average brightness and illumination figures representative of motion picture practice today. Neither can the committee make definite recommendations yet concerning the technique to be used, particularly in the determination of screen brightness. The committee believes now that a truly successful and most useful brightness meter for motion picture survey usage should be a physical measuring device rather than a visual photometer. At least two manufacturers are engaged in the development of such instruments and the committee will examine these units to determine their practicability for the task involved.

Although definite plans have not yet been formulated, it is the hope and intent of the committee that this work be continued more extensively to arrive at the objectives of specifying equipment and test methods for accurately measuring brightness and illumination on the screen and of determining present practice in the theaters. It is believed the industry will then be in a proper position to make the most effective utilization of available equipment and to maintain screen lighting in line with recommended practice.

SCREEN-BRIGHTNESS COMMITTEE

E. R. GEIB, *Chairman*

HERBERT BARNETT	W. W. LOZIER	C. R. UNDERHILL
F. E. CARLSON	*V. A. SILARD	H. E. WHITE
SYLVAN HARRIS	*M. H. STEVENS	A. T. WILLIAMS
W. F. LITTLE	C. M. TUTTLE	R. J. ZAVESKY

*Advisory members.

REFERENCE

(1) R. J. Zavesky, C. J. Gertiser, and W. W. Lozier, "Screen illumination with carbon-arc motion picture projection systems," *J. Soc. Mot. Pict. Eng.*, vol. 48, p. 73; January, 1947.

DISCUSSION

MR. HENRY GREENSPOON: Has the Committee established what would be a desirable screen brightness for theaters?

MR. R. J. ZAVESKY: The present standard is 9 to 14 foot-lamberts as measured at the center of the screen, with the projector running but with no film in the gate. Whether that standard will be changed I am not prepared to say.

MR. ABE KESSLER: As I understand, all the concerns that sell equipment—motors, generators, rectifiers, projectors—are not equipped to advise a man who is going to build a theater and who comes to the supply houses for advice. They are not equipped to advise him just what to get for a different throw considering the size of the house, and other matters.

Why should they not be supplied with proper information? They should know the right type of equipment to sell.

MR. ZAVESKY: By finding out the present practice in theaters, by proper measuring instruments, and by knowing what each piece of equipment will deliver, it will be a natural evolution that that sort of thing will occur: the equipment in the theater will be matched to meet the standards set up by the SMPE.

MR. RONALD BINGHAM: Knowledge of the surrounding brightness is very important in interpreting the data such as you have given. Is there any intent on the part of the Committee to gather data on the screen-brightness level, excluding projected light?

MR. ZAVESKY: That is part of the longer-range objective of the committee, but it has not been a part of the immediate program. The initial phases are

aimed mainly at determining what methods and equipment should be used to measure brightness and illumination and to determine what is the present practice. Some of those other things we all hope will come along a little later in the program.

MR. MATTHEW J. KEEHAN: I assume that during the course of your survey you did not visit any studios. Do you intend to do so?

MR. ZAVESKY: Not at the present moment. The main intent is to determine the practice in motion picture theaters.

MR. JOHN FERGUSON: There was one point on which I was not exactly clear. You mentioned that 50 per cent of the theaters were getting 75 per cent of the available light. Do you mean that there were misadjustments in the equipment or do you mean that the equipment was rated at a higher rating than the theater actually was using?

MR. ZAVESKY: Data have been published in the JOURNAL indicating the total quantity of light that could be expected from various combinations of arcs and optical systems. Those data were taken into consideration along with the exact projection equipment in the theater, and the ratio of that which could be expected to that which was actually measured was shown in Fig. 7. The committee did not investigate why that difference occurred.

MR. BEN SCHLANGER: The factor of the screen itself and the light coming from it represent additional items that are elusive. I wonder if this report will include that eventually? One is the age of the screen; two, the location of the screen, the atmospheric condition; three, the polar characteristic of the screen.

Unless we investigate all of these things, the changing factor of what you are getting off that screen is amazing. Unless we add those data we do not know what actually is getting to the people's eyes.

MR. ZAVESKY: The age of the screen with its condition was not specifically investigated. The committee went into the theater and measured what the condition was at the moment. Whether it was a new screen or an old, a dirty screen or a clean screen was not taken into consideration.

With reference to the condition of the atmosphere: Since all these measurements were made without any people in the house I suppose we could assume that the atmospheric conditions were best.

We expected to consider the polar characteristic and we still hope that the information that we have will show that. You will recall the slide on which was shown where and how the brightness was measured The brightness reading was taken at the center of the screen and at the upper left- and lower right-hand corners, from four extreme positions in the theater.

When we have sufficient information available from a more intensive survey, all of those data can be analyzed to tell what is the polar characteristic of the screen. While the indications are not definite, yet they tend to show that the screens all were matte and had a fairly uniform reflectivity within the angles encountered in the particular theaters surveyed.

MR. SCHLANGER: What brightness is best for different density conditions of film or what lambert will produce the best contrast value for discerning image detail? The light values alone will not give us the ultimate answer unless we have tests made with actual film strips.

MR. ZAVESKY: That point is realized by the committee, but the committee

chose to consider first things first. One of the basic unknowns was the present value. Once that is determined, our activity can be enlarged to include such very pertinent questions as you have raised.

MR. SCHLANGER: Will not that affect the recommended foot-lambert measurement?

MR. ZAVESKY: It probably will if it is demonstrated by proper tests that the standards should be changed. Right now the standards are 9 to 14 foot-lamberts.

MR. GEORGE LEWIN: Could you give us a little more detail as to the type of instrument with which you measured the brightness?

MR. ZAVESKY: That was a Luckiesh-Taylor visual photometer.

MR. LEWIN: I am not familiar with that. Can you tell definitely what part of the screen you are looking at when you look through the instrument? Is it a focused image?

MR. ZAVESKY: You can use either a view finder—which we did in some instances—or by locating on the screen at the same time some one is measuring illumination with a photronic cell, it is possible to tell where you are on the screen and knowing the angle of acceptance of the instrument and the distance you are, you can tell what portion of the screen you are actually measuring when you are measuring brightness.

MR. LEWIN: I assume, then, you did not use the Weston instrument that is available to a limited extent right now?

MR. ZAVESKY: For measuring brightness?

MR. LEWIN: Yes.

MR. ZAVESKY: I am not familiar with that one.

MR. LEWIN: It is a foot-lambert meter which has been put out on a small scale.

MR. N. D. GOLDEN: Based upon your findings that you projected on the screen there, the wide variance of percentages that you have found as conditions exist in different theaters, would you not come to the conclusion that possibly a great deal of the fault is based upon the poor quality or outmoded use of the screens and possibly the projection equipment used in the theaters that you measured?

MR. ZAVESKY: I do not think the Committee has done enough to take any stand at all on that, Mr. Golden.

MR. GOLDEN: Because of the wide variance in your percentages found—in some cases your results were of a higher degree and in a great many cases they were of low degree—you can, therefore, come to but one conclusion: Either the screens were old, dirty, and outmoded, or the light sources projected from the projection room were not adequate.

MR. ZAVESKY: Certainly if you are investigating the basic reasons for those things which were discovered, you have two factors to consider: what light is projected to the screen and what is reflected. So that on a very broad generalization the reasons why the brightness was not up or why the light intensity was not what it might have been have to be attributed to one or the other. That was not determined in this survey.

MR. GOLDEN: I quite understand that, but I think it would be the object of your Committee to find out whether or not the equipment in use in the theaters of the country, screens, projection equipment, light sources, and everything involved needs replacing and can very well stand it.

MR. ZAVESKY: Your suggestion will certainly be given consideration by the committee, Mr. Golden.

MR. JOHN H. KURLANDER: One of the items measured there was the projection distance. I noticed that the projection distance was measured from the aperture to the screen. Now I have always considered that the projection distance was measured from the front surface of the lens nearest the screen to the screen itself. The projection lens constitutes the last light source in the train. It is true that the screen there is rather small. However, inasmuch as the foot-candles on the screen are determined absolutely by the brightness of the lens and the lens area, the effective lens area—and that varies inversely as the square of the distance—that discrepancy becomes somewhat larger. Why was the distance chosen as being from the aperture to the screen?

MR. ZAVESKY: It is more a question of saying that it was from the aperture to the screen rather than a specific measurement. The determination of that distance was made by measuring from the screen to the point in the theater on a parallel under which we estimated the projector to be, and then calculating from the projection angle what the actual distance was.

I am quite sure that those figures are not accurate to better than 6 inches, but even considering the shortest throw, a 65-foot throw, an error of plus or minus 6 inches, will be not more than 1 per cent.

MR. KURLANDER: I brought that up merely for the sake of accuracy because the projection distance is actually measured from the last lens in the system, and that is the projection lens to the screen.

The second point is with regard to the relatively low values of reflection factors for these screens. Was that reflection factor determined on the basis of an integrated effect over an appreciable area of the screen which took into account the screen perforations or was that intended to represent the coefficient of reflection of the screen surface itself, that is, the reflecting efficiency of the screen surface?

MR. ZAVESKY: That was determined by taking the ratio of the brightness measured at the center of the screen to the light intensity at the center of the screen. The brightness-measuring instrument probably did not include more than an area of 1 to 2 square feet. It certainly took into consideration if there were holes in the screen as it existed in the theater at the center.

MR. KURLANDER: It was an integrated effect?

MR. ZAVESKY: For a small area at the center of the screen.

MR. KURLANDER: There again the actual coefficient of the reflection of the screen surface would be higher than is shown.

MR. ZAVESKY: You mean of the unperforated screen?

MR. KURLANDER: That is right.

MR. ZAVESKY: I expect it would be.